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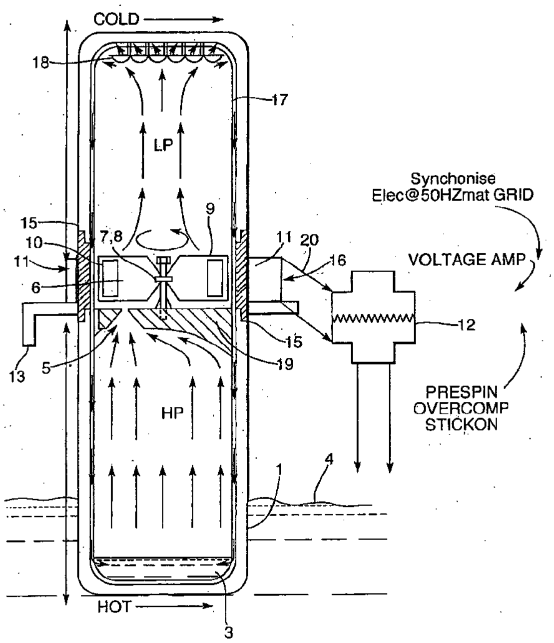
(58) Field of Search:
INT CL **F01K**
Other: **EPODOC, WPI**

(54) Abstract Title**: A heat pipe electricity generator**

(57) A heat pipe 1, which comprises a heat transfer fluid 3 in a sealed vessel 1, is able to generate induced electricity from the evaporating fluid when in use. The heat pipe comprises a turbine 9 which extracts kinetic energy from the rising vapours, the turbine being provided with magnets 10 which rotate with the turbine to induce electricity in the coils 11 located externally of the heat pipe. A nozzle 5 may direct the rising vapours towards the turbine blades as it moves from the hot to the cold end. The coils may be wired up to power an electronics module 12. Preferably the vessel is evacuated, and the heat transfer fluid 3 within is water, but could also be ammonia, alcohol, refrigerants, or a mixture of fluids. Condensed fluid 18 may be returned by capillary action. Ideally, this device is used to extract energy from the waste water 4 coming from steam turbine power stations.

Fig.1.

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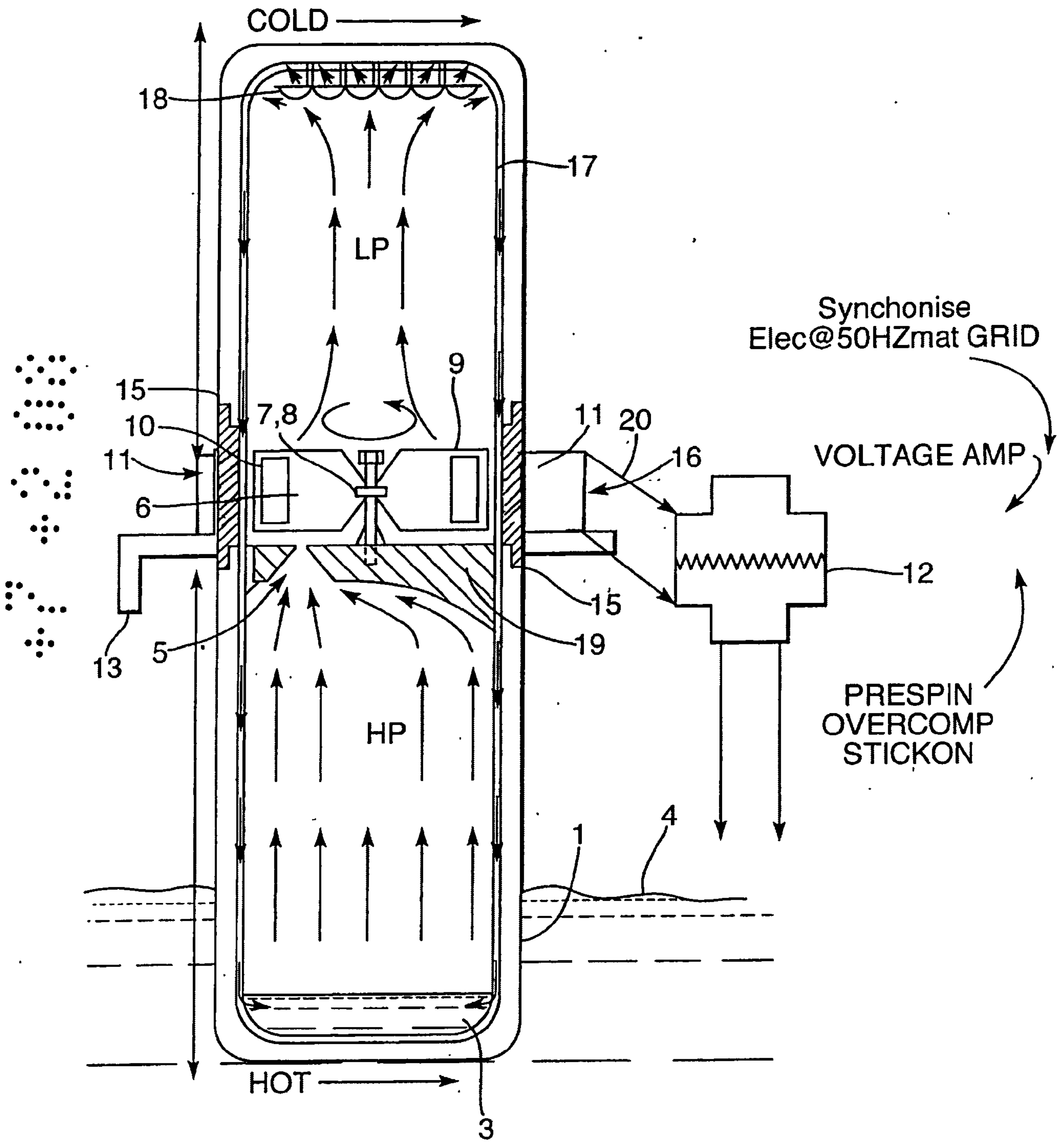
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.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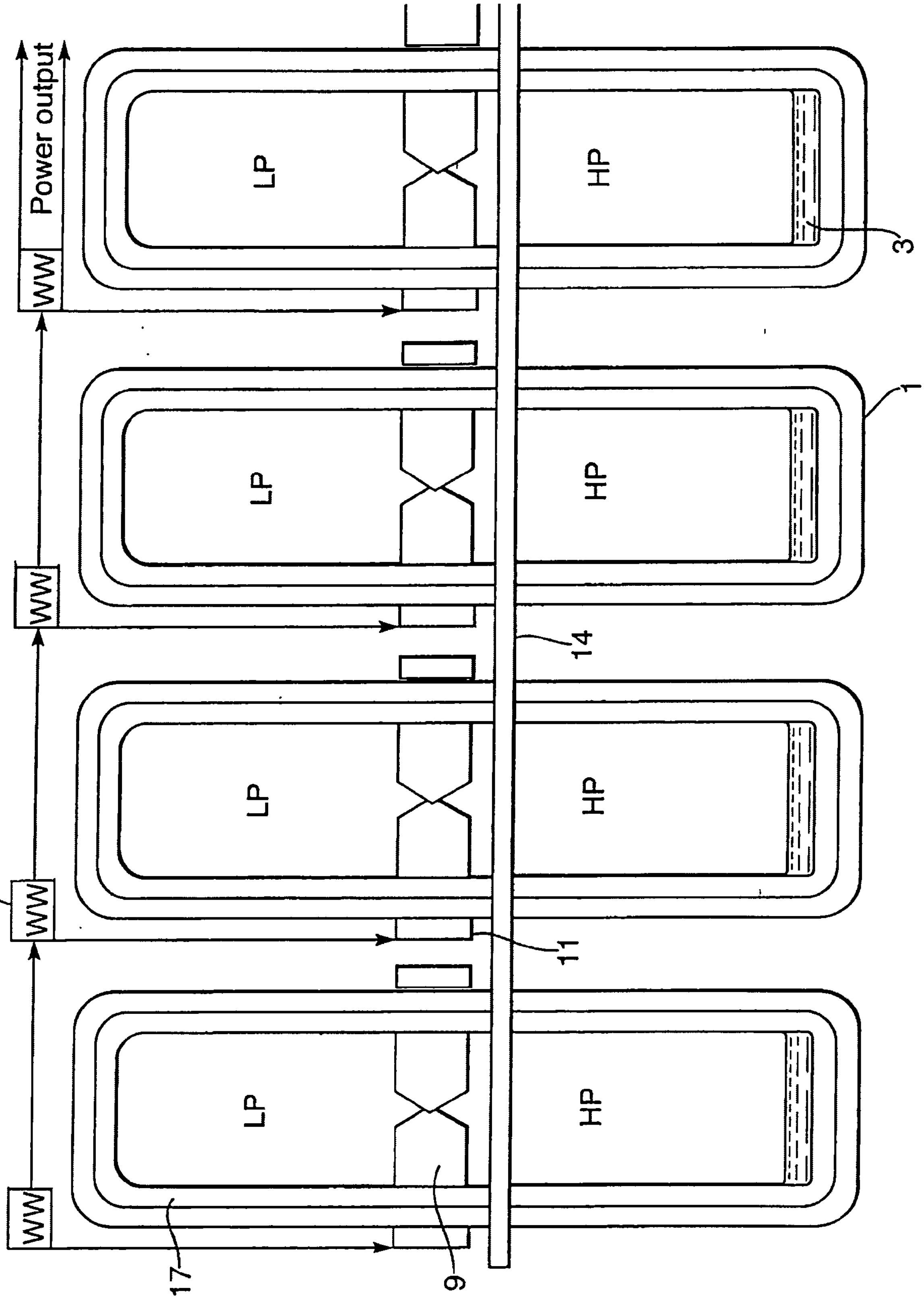



Fig.2.

Fig.3.

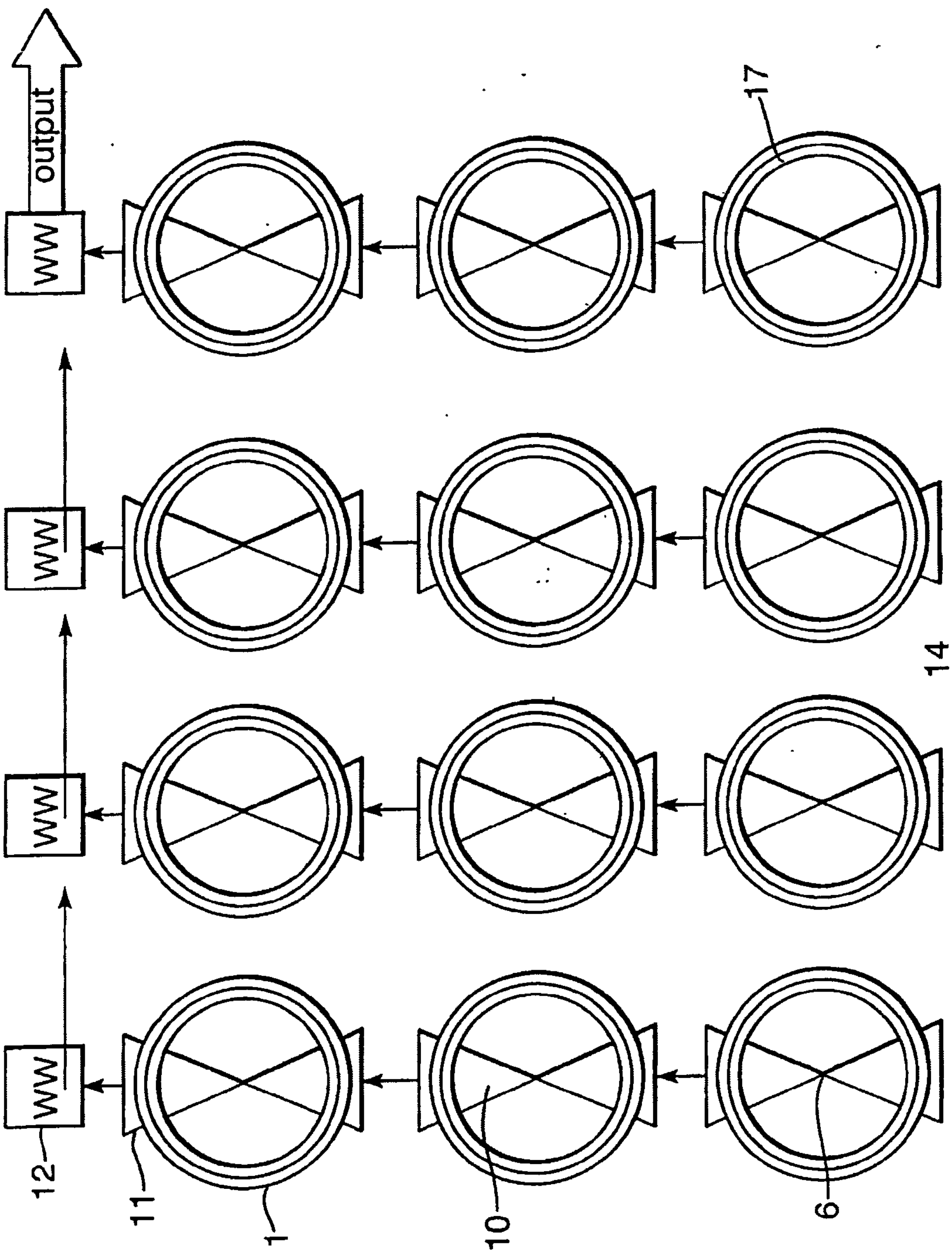


Fig.4.

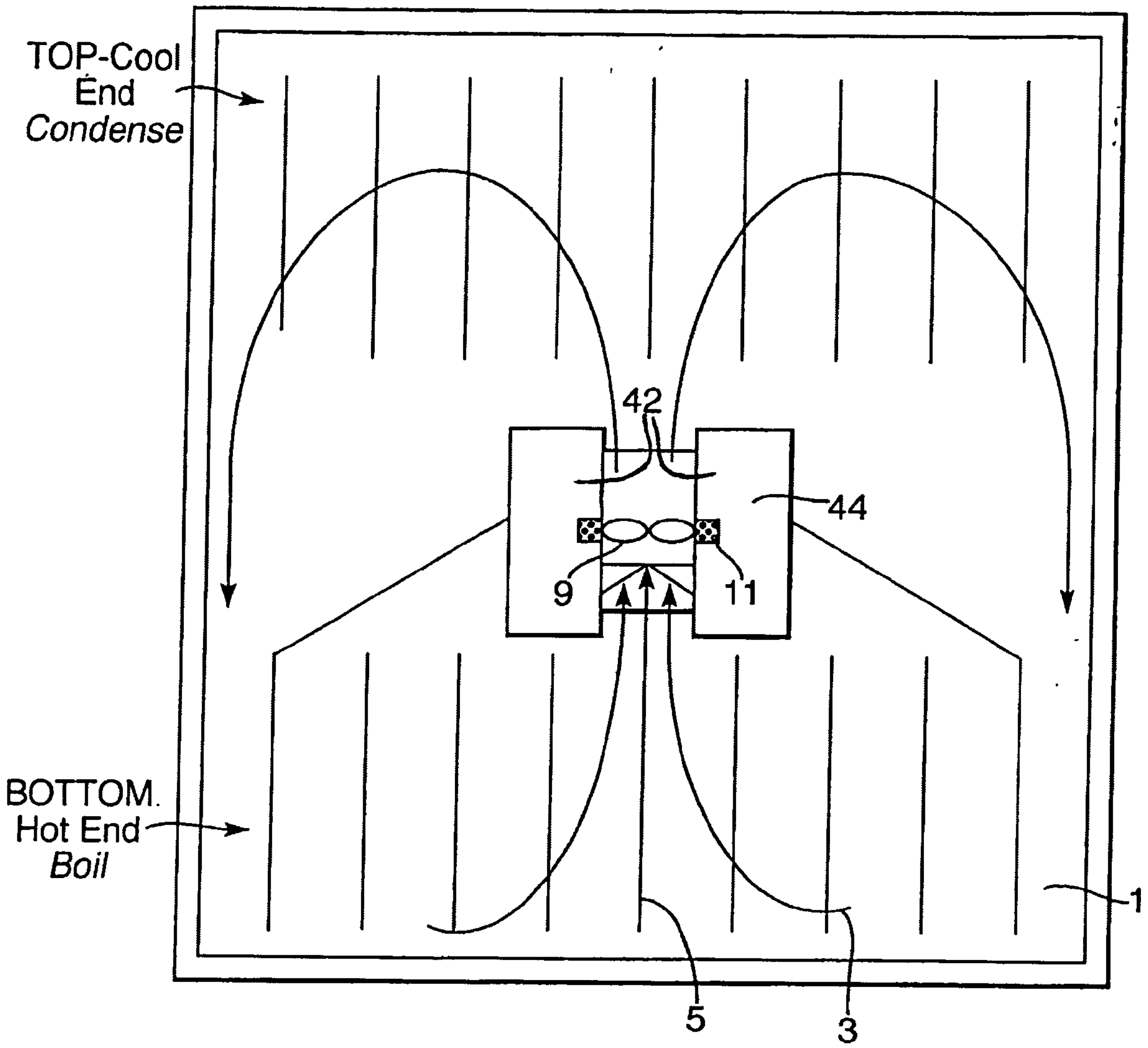
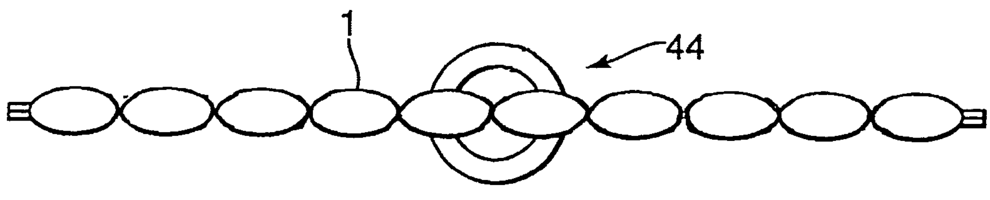



Fig.5.



## Generation of Electricity

The present invention relates to the generation of electricity, and in particular to a power generating heat transfer vessel for the direct generation of electricity from low grade waste fluid

In the majority of modern power generation facilities and power stations electricity is generated using steam-driven turbine generators. Many different methods for firing the boilers to create the steam (to power the turbine generators) are available, and may involve the use of oil-firing, gas-firing, coal-firing, nuclear power, geo-thermal energy etc. The steam enters the turbine generators at very high temperatures and pressures (the steam is "super-heated" and may be at a temperature of approximately 500°C) The super-heated steam powers and turns the turbine blades which in turn are linked to electric generators to create the electricity output. The steam leaves the turbine in the form of lower pressure and temperature steam (for example, it may be at a temperature of approximately 300°C). The lower temperature steam is then condensed in a condenser into feed water (having a temperature of approximately 50 °C) for the boiler. The condenser is itself is cooled, normally by large quantities of fresh cold water (at approximately 20 °C) from rivers, lakes, seas, purpose built cooling ponds or cooling towers. The condenser exiting cooling water streams are significantly raised in temperature (for example, to approximately 50 to 60 °C) to that of the inlet cooling water.

This warmed cooling water stream is generally considered to be of too low a temperature to enable any further direct electrical power generation by current methods. Most power stations output a huge quantity of such warmed cooling water to the environment either by direct discharges to sea, river courses or via cooling towers to the atmosphere. These warmed cooling water releases cause a detrimental effect on the local water courses and the local environment This warmed water still contains a huge amount of energy which could still be harnessed to generate electrical energy or other useful energy.

One known method of transferring heat from a hot fluid to a cold fluid involves the use of heat pipe technology. A heat pipe is a cylindrical vessel which contains a heat transfer medium, the boiling point of which is modified by altering the internal pressure within the sealed vessel of the heat pipe. Thermal/heat energy is moved from the hot end of the heat pipe to the cold end via the latent heat of vaporisation of the medium (at the hot end), convection heat transfer (by the vaporised internal medium fluid) and then condensation of the vaporised medium at the cold end of the heat pipe vessel. This heat transfer process may be enhanced by the presence of a porous internal lining to the heat pipe vessel, which effectively increases the available surface area for the heat transfer medium vaporisation and condensation. It also gives a route/channel for the medium condensate to return to the vaporisation end of the tube via capillary action and gravity. A heat pipe works better when placed vertically.

JP 62-163558 discloses a heat pipe type generator for generating power from heat energy. Waste water is used to heat an electro conductive heat medium, which is thus caused to vaporise. As the vapour passes through a magnetic field, electrical energy is generated within orthogonally arranged electrodes. The system disclosed in this document relies on an electroconductive medium.

JP 57-148011 discloses a motive power generator. A circulating force is formed by using low temperature waste heat to evaporate water. Steam is then forced through a nozzle. The jets drive a flow turbine that in turn causes an electricity generator to produce electric power. A disadvantage of this system is that the generator is located within the vessel, making maintenance extremely difficult. This arrangement requires electrical connections to be made inside the vessel. Moreover, the generator can inhibit the steam flow. There is also an opening into the vessel which can lead to its premature failure.

According to a first aspect of the present invention there is provided an electricity generator including: a vessel having an interior sealed from the atmosphere; a heat transfer fluid within the interior of the vessel; an electric current receiving means for introducing an electric current into a circuit, an electric current inducing means for inducing an electric current into the electric current receiving means, the electric current inducing means arranged to be driven by evaporation and/or convection of the heat transfer fluid.

Preferably, the electric current receiving means is physically isolated from the interior of the vessel.

Provision of an electric current receiving means isolated from the interior of the vessel means that electrical connections do not need to be made within the vessel. This renders the generator simpler and increases its reliability. The electric, current receiving means does not interfere with the flow of evaporated and convected heat transfer fluid, and is easier to maintain and install when isolated from the interior of the vessel. Moreover, ensuring that the electric current receiving means does not take up space within the vessel means that the size of the electric current inducing means can be maximised.

In some embodiments, the electric current receiving means may be located within a recess of the internal wall of the vessel in order to help maximise space available within the vessel for the electric current inducing means.

The electric current receiving means may be located outside the vessel or may be located at least partially within the wall of the vessel. It may be embedded within the wall of the vessel or be located between two layers of the wall of the vessel, for example.

The electric current receiving means preferably includes a coil This allows electric current to be induced therein.

The electric current inducing means preferably includes a movable magnet This is able to interrupt lines of flux created by the electric current receiving means and thus induce electric current therein.

The moveable magnet is preferably fixed to, incorporated in, or integral with a blade of a fan. This provides a convenient means of moving the magnets

Preferably, the magnet is a rare earth magnet. These are particularly suitable for use in an electric generator.

Preferably the vessel is located at least partially within a waste fluid conduit such that heat from waste fluid is able to heat the heat transfer medium.

By locating the vessel at least partially within a waste fluid conduit, heat from waste fluid generated as a by-product, for example, from industrial processes, and which would otherwise not be recycled, can be used to generate an electric current This recycling allows harnessing of energy that would otherwise be wasted directly from hot water.

Preferably, the heat transfer fluid is not an electroconductive fluid. In particular, the heat transfer fluid is preferably water. Water is cost-effective and non-toxic It also evaporates under suitable temperature/pressure conditions.

In an embodiment, the vessel is at a pressure lower than atmospheric pressure. Reduction of the pressure within the vessel enables the heat transfer fluid to evaporate at lower temperatures.

The pressure within the vessel may be selected to allow the heat transfer fluid to evaporate at a temperature of approximately 20°C, or at a temperature of approximately 60°C, for example. If the heat transfer fluid is able to evaporate at a low temperature, heat from waste water can more efficiently be used to generate electricity

In the preferred embodiment, the vessel incorporates directing means for directing a flow of evaporated and/or convected heat transfer fluid towards the electric current inducing means. Such directing means ensures that as much of the energy within the evaporated heat transfer fluid as possible is used to drive the electric current inducing means.

The directing means preferably also increases the speed of flow of the evaporated and/or convected heat transfer fluid. The faster the heat transfer fluid flows, the more electricity can be generated from the electric current inducing means.

The directing means may comprise an obstruction to the flow of evaporated and/or convected heat transfer fluid, the obstruction including an opening to allow a restricted passage of evaporated and/or convected heat transfer fluid. This provides a simple and effective means of directing and/or speeding up the flow of evaporated heat transfer fluid

The opening is preferably offset from the centre of a transfer cross section of the vessel Directing the flow of evaporated heat transfer fluid in this manner onto the electric current inducing means may result in more efficient driving of the electric current inducing means.

The vessel may include a coating on its internal wall, the coating being selected to facilitate condensation of the heat transfer fluid. The coating is preferably a porous coating. Preferably, the vessel includes a condensation feature at its upper end to facilitate condensation of the heat transfer fluid. Increasing the rate of condensation of the heat transfer fluid increases the rate of overall rate of flow of the heat transfer fluid.

A portion of the wall of the vessel may be fabricated from a material that propagates lines of flux from the electric current receiving means. Preferably, the portion of the wall is fabricated from a non-metallic material, such as a polymeric material, or a composite material. The stronger the lines of flux, the more efficient the electrical induction

In the preferred embodiment, no cooling means is provided Allowing the ambient temperature to form a cool portion of the vessel for condensation of the heat transfer fluid saves energy.

According to a third aspect of the present invention there is provided an array of a plurality of generators.

Provision of a plurality of generators in an array allows scaling up of the electricity generation

Preferably the electric current inducing means in at least two of the generators of the array are synchronised. This helps to optimise power generation and direct generation of AC electrical power.

According to a second aspect of the present invention there is provided a method of generating electricity including heating a heat transfer fluid within a sealed vessel thereby causing evaporation of the heat transfer fluid, using the vaporised heat transfer fluid to drive an electric current inducing means located within the vessel, and inducing an electric current within an electric current receiving means located outside the vessel.

Preferably, the electric current receiving means is physically isolated from the interior of the vessel.

Heat from a waste fluid may be used to heat the heat transfer fluid thereby causing evaporation of the heat transfer fluid.

Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig.1 is a schematic diagram of an electricity generator;
Fig.2 shows a side view of an array of electricity generators;

Fig 3 shows a plan view of an array of electricity generators,
Fig 4 shows a front view of a second embodiment of an electricity generator; and
Fig 5 shows a plan view of a second embodiment of an electricity generator.

Referring to Figures 1, 2 and 3, an electricity generator in accordance with a preferred embodiment of the invention includes a sealed cylindrical vessel 1 (which in this embodiment is a heat pipe) containing water 3. The vessel is preferably fabricated from copper (which could be nickel-coated), aluminium, stainless steels or alloys of any of these).

The vessel is preferably approximately 30 cm long and has a diameter of 5 cm. The vessel 1 is partially evacuated in order that it is held below atmospheric pressure A suitable pressure may be 300 millibar absolute pressure. This serves to lower the boiling point of the water 3 held therein and thus the temperature at which the water 3 will evaporate.

The vessel 1, in use, comprises a lower, "hot" end, and an upper "cold" end The hot end may be at a temperature of approximately 60°C, the cold end may be at a temperature of approximately 20°C.

The vessel 1 includes a continuous internal porous lining or coating 17 that extends along the full length of the vessel 1 and across the central section 16. This provides a porous condensate-return route for vaporised water 3 that has subsequently condensed at the upper end of the vessel 1. The upper end of the vessel 1 preferably includes a condensation feature 18 to improve the efficiency of this condensation.

Approximately midway along the length of the vessel 1, a fan 9 is internally mounted. The fan 9 is preferably plastic injection moulded The spindle 6 of the fan 9 is arranged co-axially with the longitudinal axis of the vessel 1 and substantially centrally within the vessel 1 Low friction bearings 7 (which could be of ceramic or plain bearing material) are located within a plastic injection moulded housing 8 to allow the fan 9 to rotate more freely Rare earth magnets 10 are fixed to each fan 9 blade. In the preferred embodiment the fan 9 blades extend as far as possible from the spindle 6 (without touching the wall of the vessel 1) and the magnets 10 are located as far as possible towards the extremities of the fan 9 blades so that they are located as close to the internal wall of the vessel 1 as possible.

Mounted externally to the vessel 1, and at the same level along the length of the vessel 1 as the fan 9, are electric coils 11. These are, in turn, electrically connected via wiring 20 to a power electronics module 12. The coils 11 provide a plurality of lines of flux traversing the diameter of the vessel 1. A central section 16 of the wall of the vessel 1 that is non-absorbent to magnetic radiation and lines of flux is preferably fabricated from a non-metallic material This serves to facilitate propagation of the lines of flux from the electric coil(s) 11

The fan 9 is mounted via its spindle 6 to a platform 19 extending inwardly from the interior wall of the vessel 1 The platform 19 includes an opening 5, which in the preferred embodiment is offset from the centre of the platform 19. The opening 5 provides a restricted pathway for the passage of vaporised water 3. The purpose of this is described below.

The vessel 1 may be formed in two or more parts, thereby including a split 15 This enables the fitting of the internal turbine 9 assembly. A bracket 13 is attached to the outside of the vessel 1 to facilitate vertical placement and secure fixing of an individual vessel 1 on to a plate 14. For use, the vessel 1 is located partially within the waste water 4 pipe of a power station, such that the lower hot end of the vessel 1 is located within the waster water 4 that may be at a temperature of approximately 60°C and is thereby heated.

It is preferred that a plurality of electricity generators are provided in an array Figures 2 and 3 illustrate such arrays.

In use, heating of the hot end of the vessel 1 causes the water 3 to evaporate Because the vessel 1 is at a pressure lower than atmospheric pressure, the boiling point of the water 3 is reduced to less than 100°C. The water is thus able to evaporate at a relatively low temperature, such as 60°C.

The upwardly moving vaporised water 3 is guided or channelled through the opening 5 in the platform 19. The opening 5 serves to restrict the flow of the vaporised water 3, thereby increasing its speed. The offset position of the opening 5 orientates and concentrates the vaporised water 3, thereby forcing the moving vaporised water 3 onto the blades of the fan 9 and causing them to rotate.

Rotation of the fan 9 causes the magnets 10 located on the blades of the fan 9 to interrupt the lines of flux from the coils 11. This causes induction of electric current within the wires of coil 11. This electric current is then collected by the power electronics module 12 mounted on the outside of each vessel 1.

The vaporised water 3 that has driven the fan 9 then passes to the cold end of the vessel 1 The water 3 condenses at the cold end then returns under capillary action and gravity down to the hot end of the vessel 1.

There are several advantages to the above-described embodiment.

Location of the coils 11 outside the vessel 1 means that electrical connections do not need to be made inside the vessel. This reduces manufacturing cost and increases generator reliability. It also means that the coils 11 do not restrict the flow of the steam. Maintenance, assembly and connection of the coils 11 (for example, in manufacture, monitoring, installation or fault finding) is also facilitated.

Location of the fan 9 internally within the vessel 1 enables the kinetic and thermodynamic energy of the vaporised fluid flow to be converted directly into electrical energy in a highly efficient manner for a relatively small device.

As the vessel 1 is sealed, the internal rotating workings of the vessel 1 are self-protecting and the generator overall requires very little maintenance.

The simplicity of the generator allows it to be scaled up into a matrix/array/module of generators to create a larger power-generating surface/device that can be optimised for each application to create the maximum electrical energy-generation from the hot water present. Advantageously, in the unlikely event that an individual generator should fail, the entire power-generating surface device would remain functional. A single faulty vessel could be replaced as a unit, thereby facilitating easy and cost-effective maintenance. Large-scale and low-cost production of individual vessels 1 will enable economies of scale to be employed to reduce the cost per vessel

The outer electric coil 11 is sited locally to the spinning fan 9 but on the outside of the vessel 1 via the power electronics will enable the internal fan 9 to be controlled for the purposes of pre-spin to overcome friction and synchronisation with the other generating vessels to ensure optimum power generation and direct generation of AC electrical power, for example by phase synchronisation.

A particular advantage of the above-described embodiment is that the cold end is cooled using ambient air. The main advantage is that during the night time or during the winter periods the ambient air temperature is low thereby creating a larger temperature differential gradient (between the ambient air and the hot waste water). This results in a greater motive power via the vessel 1 and the fan 9 for the generator. Hence the generator works better in the winter when the electrical demand is higher than in the summer.

Location of the magnets 10 as close to the internal wall of the vessel 1 as possible essentially maximises the electricity that can be generated from a given size of vessel 1, whilst avoiding induction of a high pressure differential loss across the blades, which would reduce the induced flow of vaporised heat transfer medium.

There are many modifications that can be made to the above-described embodiment.

The coils 11 need not be located outside the vessel 1. They could be incorporated within the wall of the vessel 1. For example, they could be incorporated within the central section 16, which could be manufactured as a separate unit for use in the described generator The coils 11 could be embedded within the wall of the vessel 1 or located between layers of the wall of the vessel 1. In some embodiments the coils 11 could be located inside the vessel but within a recess so as not to extend into the interior volume of the vessel.

The vessel 1 need not be cylindrical, it could be any suitable shape. For example, it could have a square or hexagonal cross-section and may be extruded

The heat transfer medium need not be water 3. It could be any suitable fluid that, for example, at low pressures is easily vaporised at a temperature below its atmospheric vaporisation temperature (boiling point). Depending on the application, the fluid could be water, ammonia, alcohols, liquid sodium, Freon and other refrigerants or mixtures of some of these (ie those that do not react like water/alcohols mixtures), for example.

Whilst rare earth magnets 10 are preferred, any suitable magnet could be used.

The vessel 1 could be supported by any suitable plate or support bracket or any other suitable means.

The central section 16 need not be metallic. It could be polymeric or composite to perform the same function.

Tubular or flat arrays of vessels 1 are also envisaged. The flat arrays could be mounted vertically in channels.

The vessel 1, heat transfer medium 3 and internal pressure/vacuum conditions can be varied to optimise the operation of the generator for specific application conditions. This enables further efficiencies of electric power generation to be obtained.

The size of the vessel 1 will depend on the particular application. It may have a length of 8 cm to 50 cm, for example, preferably 20 cm to 30 cm. In some applications, the vessel 1 may be many metres in length. The diameter of the vessel may also vary. It could be approximately 1.5 cm, approximately 2.5 cm to 8 cm or approximately 5 cm, for example.

Similarly, the internal dimensions, shape and design of the condensate return lining 17 can be modified to improve condensate return without affecting the kinetic and thermodynamic motive power of the upward moving vaporised heat transfer fluid 3 which drives the fan 9.

The fan 9 need not be positioned midway along the length of the vessel 1. Other positions may be suitable.

The opening 5 need not be offset, it could be positioned substantially centrally.

In some applications, it might be preferred actively to cool the cold end of the vessel 1. This could be done using a cooling fan, for example. Alternatively, this could be done using cold water, a refrigerant, or cooled air amongst many other possibilities. This may help to increase the temperature differential between the hot end and the cold end, thereby increasing the efficiency and speed of vaporisation of the water 3 or other heat transfer medium

The vessel 1 could be designed to allow vaporisation of the heat transfer medium 3 at temperatures as low as 20°C or even as low as -5°C for permafrost applications (see below).

The above-described generator could also be used on a smaller scale in other situations. For example, it could be suitable for domestic and institutional users to recover useful electrical energy from domestic hot water released to the drains.

Whilst the above embodiment has been described with reference to recycling heat energy from waste water, many other applications may be envisaged For example, in the artic regions of the world the "hot" end of the vessel could be located in the permafrost ground (at a temperature of around -5°C). The cooler air temperature (that may be around -40°C) would create sufficient temperature differential for evaporation of a suitable heat transfer fluid. In such applications, the heat transfer medium could be, for example, ammonia, water, alcohols, or mixtures thereof. Geothermal applications could involve the "hot" end of the vessel being placed within hot springs (for example, at a temperature of around 200°C). In these applications, the ambient air temperature may be at around 10-20°C and the heat transfer fluid could be water, or even sodium. Subterranean applications may involve the "hot" end being at a temperature of around 10°C with the ambient air temperature cooling the "cold" end to -10°C or lower. The heat transfer fluid could, in such an application, be water, alcohols or water-alcohol mixtures. A desert sand application could involve the "hot" end (at night) being in sand at a temperature of around 20°C, with the cooler ambient air temperature at around 0°C. During the day, the "hot" air temperature may be 40°C with the desert sand being at around 20°C. A suitable heat transfer fluid would be water. Deep water layers can be 15°C colder in less than a metre when a current boundary layer is passed. Ocean current layers can thus be used to provide suitable temperature differentials. These applications are merely exemplary; the skilled person would appreciate that the described generator could be used in many other applications

The skilled person will appreciate that many other modifications could be made to the above-described embodiment without departing from the scope of the claims

Figures 4 and 5 illustrate a second embodiment of a generator.

In this embodiment, the sealed vessel 1 is not a heat pipe, but is a wafer 1 constructed from two welded sheets containing channels. Its structure is thus similar to that of a domestic radiator (although other suitable shapes may be envisaged). The inside of the vessel 1 has a porous coating that is formed by a thermal metal spraying technique during manufacture. This results in deposition of a porous layer of metallic material selectively onto the internal faces of the metal sheets prior to their being joined together.

Holes 42 are provided within the wafer and a polymer turbine module 44 containing a miniature heat pipe-type structure containing a fan 9 separated from the coils 11. The coils 11 are thus situated outside the heat pipe-type structure.

Internal guides create channels within the wafer 1. These increase the kinetic energy of the flow of heat transfer vapour, which in turn increases the efficiency of electricity-generation.

The embodiment illustrated in Figures 4 and 5 lends itself to cost-effective manufacturing techniques whilst increasing surface area through use of a joined (welded or soldered) metal wafer construction. The internal guides/channels assist return of condensed water to the base of the wafer 1 by both gravity and capillary action whilst maintaining a low pressure differential over the fan 9. This helps to optimise electric power-generation.

In this embodiment, the turbine may be manufactured as a polymer moulded module 44 containing integral coils 11, fan 9, and magnets 10, which is fixed into the wafer 1 during the production process. This facilitates manufacture and assists travel of the magnetic flux through the polymer moulding.

It can be seen from the above that the described electricity generators harness the flow of a vaporised heat transfer medium and pressure from the hot end of the vessel 1 to force the vaporised fluid flow to drive an internal fan 9). Magnets 10 incorporated in the blades of the fan 9 cut lines of flux and induce current in a set of external coils 11 which are located on the outside of the vessel 1 close to the fan 9 These generators are thus able to extract electrical energy directly and efficiently from hot water sources, such as the low grade waste water 3 created as a by-product from power stations and industrial processes. The latent energy in such waste water 3 is not currently utilised for electrical energy generation.

A plurality of the above-described generators may be assembled into an array or matrix that can be scaled up as appropriate to suit the application, into modules. Each matrix will have the individual vessel 1-induced currents combined via power electronics into a single electrical power output. Modules can also be electrically synchronised together further to increase the electrical power output. By scaling up these vessels 1 into matrices and modules, power-generating facilities with generating capacities of megawatt capacity could be possible.

The skilled person will appreciate that modifications described with reference to the embodiment of Figures 1, 2 and 3 may be applied to the embodiment of Figures 4 and 5 as appropriate

The Abstract accompanying this application is incorporated herein by reference.

## Claims

1 An electricity generator including:

a vessel having an interior sealed from the atmosphere;

a heat transfer fluid within the interior of the vessel;

an electric current receiving means for introducing an electric current into a circuit,

an electric current inducing means located within the vessel for inducing an electric current into the electric current receiving means, the electric current inducing means arranged to be driven by evaporation and/or convection of the heat transfer fluid.

2. A generator as claimed in claim 1, wherein the electric current inducing means is located within the vessel and wherein the electric current receiving means is physically isolated from the interior of the vessel.

3 A generator as claimed in claim 1, wherein the electric current receiving means is located within a recess of the internal wall of the vessel.

4 A generator as claimed in claim 1 or 2, wherein the electric current receiving means is located outside the vessel.

5 A generator as claimed in claim 1 or 2, wherein the electric current receiving means is located at least partially within the wall of the vessel.

6 A generator as claimed in claim 5, wherein the electric current receiving means is embedded within the wall of the vessel.

7 A generator as claimed in claim 5, wherein the electric current receiving means is located between two layers of the wall of the vessel.

8 A generator as claimed in any preceding claim, wherein the electric current receiving means includes a coil.

9 A generator as claimed in any preceding claim, wherein the electric current inducing means includes a movable magnet.

10. A generator as claimed in claim 8, wherein the movable magnet is fixed to, incorporated in or integral with a blade of a fan.

11 A generator as claimed in claim 8 or 9, wherein the magnet is a rare earth magnet.

12 A generator as claimed in claim 1, wherein the vessel is located at least partially within a waste fluid conduit such that heat from waste fluid is able to heat the heat transfer medium.

13. A generator as claimed in any preceding claim, wherein the heat transfer fluid is not an electroconductive fluid.

14 A generator as claimed in any preceding claim, wherein the heat transfer fluid is water.

15. A generator as claimed in any preceding claim, wherein the vessel is at a pressure lower than atmospheric pressure.

16 A generator as claimed in any preceding claim, wherein the pressure within the vessel is selected to allow the heat transfer fluid to evaporate at a temperature of approximately 20°C.

17 A generator as claimed in any preceding claim, wherein the pressure within the vessel is selected to allow the heat transfer fluid to evaporate at a temperature of approximately 60°C.

18 A generator as claimed in any preceding claim, wherein the vessel incorporates directing means for directing a flow of evaporated and/or convected heat transfer fluid towards the electric current inducing means.

19 A generator as claimed in claim 18, wherein the directing means also increases the speed of flow of the evaporated and/or convected heat transfer fluid.

20. A generator as claimed in claim 18 or 19, wherein the directing means comprises an obstruction to the flow of evaporated and/or convected heat transfer fluid, the obstruction including an opening to allow a restricted passage of evaporated and/or convected heat transfer fluid.

21. A generator as claimed in claim 20, wherein the opening is offset from the centre of a transverse cross-section of the vessel.

22 A generator as claimed in any preceding claim, wherein the vessel includes a coating on its internal wall, the coating being selected to facilitate condensation of the heat transfer fluid.

23. A generator as claimed in claim 22, wherein the coating is a porous coating.

24. A generator as claimed in any preceding claim, wherein the vessel includes a condensation feature at its upper end to facilitate condensation of the heat transfer fluid.

25. A generator as claimed in any preceding claim, wherein a portion of the wall of the vessel is fabricated from a material that propagates lines of flux from the electric current receiving means.

26. A generator as claimed in claim 25, wherein a portion of the wall of the vessel is fabricated from a non-metallic material.

27. A generator as claimed in claim 26, wherein the non-metallic material is a polymeric material, or a composite material.

28 A generator as claimed in any preceding claim, wherein no cooling means is provided.

29. An array of a plurality of generators as claimed in any preceding claim.

30. An array as claimed in claim 28, wherein the electric current inducing means in at least two of the generators are synchronised.

31. A method of generating electricity including heating a heat transfer fluid within a sealed vessel thereby causing evaporation of the heat transfer fluid, using the vaporised heat transfer fluid to drive an electric current inducing means located within the vessel, and inducing an electric current within an electric current receiving means.

32. A method as claimed in claim 31, wherein the electric current receiving means is physically isolated from the interior of the vessel.

33. A method as claimed in claim 31 or 32, wherein heat from a waste fluid is used to heat the heat transfer fluid thereby causing evaporation of the heat transfer fluid.

34 An electricity generator substantially as hereinbefore described, with reference to, and as illustrated in, the accompanying drawings.

35. A method of generating electricity substantially as hereinbefore described, with reference to, and as illustrated in, the accompanying drawings

**Application No:** GB0624320.8 **Examiner:** Mr Nithi Nithiananthan
**Claims searched:** 1-33 **Date of search:** 4 April 2007

# Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|---|---|---|
| X | 1-33 | JP2000170505 A (Fujikura); see esp. fig. |
| X | 1-33 | JP58183876 A (Honda); see esp. figs. |
| X | 1-33 | JP2001020706 A (Hashimoto); see esp. fig.1 |
| X | 1-33 | JP61255202 A (Mitsui); see esp. figs. 1 & 2 |
| X | 1-33 | JP51136052 A (Matsushita); see fig. |
| X | 1-33 | JP07180649 A (Shimizu); see esp. figs. |
| X | 1-33 | SU1134880 A1 (Inst); see esp. figs. |

Categories:

| | | | |
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| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC$^{X}$ :

Worldwide search of patent documents classified in the following areas of the IPC

F01K

The following online and other databases have been used in the preparation of this search report

| EPODOC, WPI |
|---|

**International Classification:**

| Sub Class | Sub Group | Valid From |
|---|---|---|
| F01K | 0025/00 | 01/01/2006 |
| F01K | 0025/06 | 01/01/2006 |
| F01K | 0025/10 | 01/01/2006 |